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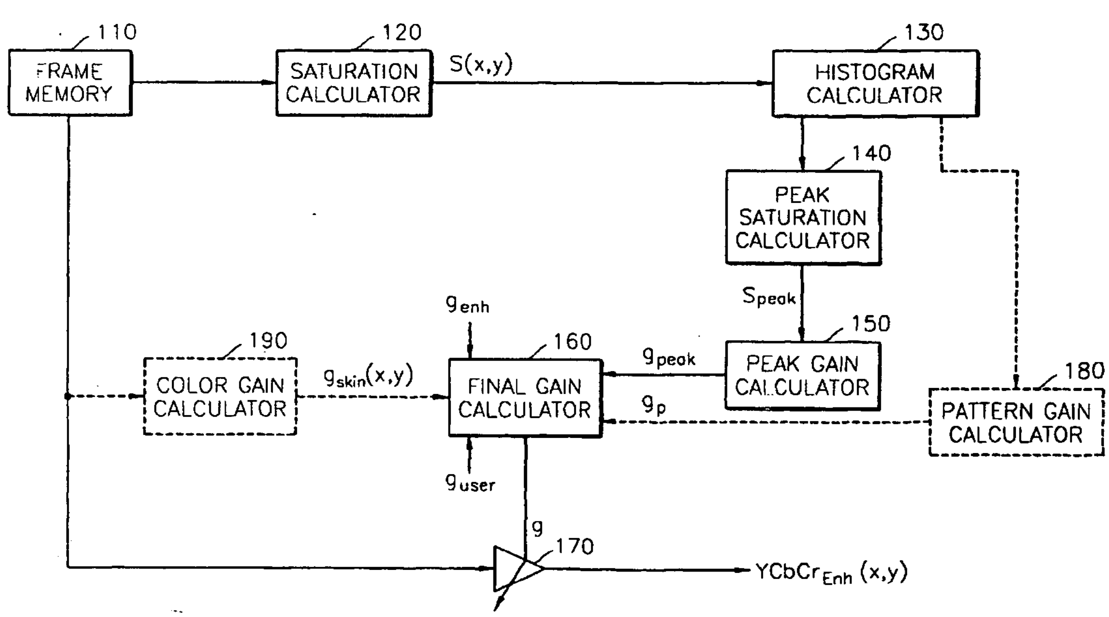
(54) Apparatus and method for adjusting saturation of color image

(57) An apparatus and method for adjusting the saturation of a color image are provided. In the saturation adjusting apparatus and method, a saturation value for each of pixels of an input image is calculated, and a peak saturation value and a mean saturation value of the input image are calculated using the saturation values of the pixels. A peak gain value based on the peak saturation value and a mean gain based on the mean saturation value are calculated. A local gain value is calculated using the mean gain value and the saturation values of the pixels. A pattern gain value for a test pattern image and a color gain value for a skin color image are also considered to adaptively adjust the saturation of the input image.

FIG. 1



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Description

[0001] The present invention relates to an apparatus and method for adjusting the saturation of a color image, and more particularly, to an apparatus and method for adjusting the color saturation of an input image in a digital TV, photoshop, digital camera, camcoder, and computer-based image processor to provide a quality image to a user.

[0002] A conventional image processor increases the saturation of an input image irrespective of the characteristic of the input image. As an example, when the background saturation is increased in a TV screen, the saturation of a facial image of persons is also increased, so that the persons appear unnatural due to the supersaturation of the skin color.

[0003] A conventional image enhancement system processes input data without considering whether or not the input data is a kind of a test pattern image, thereby making it difficult to control the quality of the image to be displayed on a particular display.

[0004] Accordingly, it is an object of the present invention to provide an apparatus and method for adaptively adjusting the saturation of an input color image in consideration of the characteristic of the input color image.

[0005] It is another object of the present invention to provide an apparatus and method for selectively adjusting the saturation in a particular region of an input image while maintaining the skin color in the input image, thereby providing a user with natural color impression.

[0006] It is another object of the present invention to provide an apparatus and method for adaptively adjusting the saturation of a color image, in which when a test pattern image is input, the saturation adjustment is bypassed to enable quality control of the image to be displayed on a particular display.

[0007] In one aspect, the present invention provides an apparatus for adjusting the saturation of a color image, comprising: a saturation calculator which calculates a saturation value for each of pixels of an input image; a peak saturation calculator which determines a peak saturation value of the input image using saturation values calculated by the saturation calculator; a peak gain calculator which calculates a peak gain value based on the peak saturation value determined by the peak saturation calculator; and a saturation adjustor which adaptively adjusts the saturation of the input image using the peak gain value calculated by the peak gain calculator.

[0008] Alternatively, the present invention provides an apparatus for adjusting the saturation of a color image, comprising: a saturation calculator which calculates a saturation value for each of pixels of an input image; a peak saturation calculator which determines a peak saturation value of the input image using the saturation values calculated by the saturation calculator; a peak gain calculator which calculates a peak gain value based on the peak saturation value determined by the peak saturation calculator; a pattern gain calculator which determines whether or not the input image is a predetermined pattern image and calculates a pattern gain value for the predetermined pattern image depending on whether the input image is determined as the predetermined pattern image; and a saturation adjustor which adaptively adjusts the saturation of the input image using the peak gain value calculated by the peak gain calculator and the pattern gain value calculated by the pattern gain calculator.

[0009] The present invention also provides an apparatus for adjusting the saturation of a color image, comprising: a saturation calculator which calculates a saturation value for each of pixels of an input image; a peak saturation calculator which determines a peak saturation value of the input image using saturation values calculated by the saturation calculator; a peak gain calculator which calculates a peak gain value based on the peak saturation value determined by the peak saturation calculator; a color gain calculator which determines whether each of the pixels of the input image belongs to a predetermined color region and calculates a color gain value for a pixel depending on whether the pixel belongs to the predetermined color region; and a saturation adjustor which adaptively adjusts the saturation for each of the pixels of the input image using the peak gain value calculated by the peak gain calculator and the color gain value calculated by the color gain calculator.

[0010] The present invention provides an apparatus for adjusting the saturation of a color image, comprising: a saturation calculator which calculates a saturation value for each of pixels of an input image; a peak saturation calculator which determines a peak saturation value of the input image using saturation values calculated by the saturation calculator; a peak gain calculator which calculates a peak gain value based on the peak saturation value determined by the peak saturation calculator; a pattern gain calculator which determines whether or not the input image is a predetermined pattern image and calculates a pattern gain value depending on whether the input image is determined as the predetermined pattern image; a color gain calculator which determines whether each of the pixels of the input image belongs to a predetermined color region and calculates a color gain value for a pixel depending on whether the pixel belongs to the predetermined color region; and a saturation adjustor which adaptively adjusts the saturation for each of the pixels of the input image using the peak gain value calculated by the peak gain calculator, the pattern gain value calculated by the pattern gain calculator, and the color gain value calculated by the color gain calculator.

[0011] The present invention provides an apparatus for adjusting the saturation of a color image, comprising: a saturation calculator which calculates a saturation value for each of pixels of an input image; a mean saturation calculator which calculates a mean saturation value of the input image using saturation values calculated by the saturation

calculator; a mean gain calculator which calculates a mean gain value based on the mean saturation value calculated by the mean saturation calculator; and a saturation adjustor which calculates a local gain value for each of the pixels using the mean gain value calculated by the mean gain calculator and the saturation values calculated by the saturation calculator and adaptively adjusts the saturation of each of the pixels of the input image using the local gain value.

[0012] The present invention provides an apparatus for adjusting the saturation of a color image, comprising: a saturation calculator which calculates a saturation value for each of pixels of an input image; a mean saturation calculator which calculates a mean saturation value of the input image using saturation values calculated by the saturation calculator; a mean gain calculator which calculates a mean gain value based on the mean saturation value calculated by the mean saturation calculator; a pattern gain calculator which determines whether or not the input image is a predetermined pattern image and calculates a pattern gain value depending on whether the input image is determined as the predetermined pattern image; and a saturation adjustor which calculates a local gain value for each of the pixels using the mean gain value calculated by the mean gain calculator and the saturation values calculated by the saturation calculator and adaptively adjusts the saturation of each of the pixels of the input image using the local gain value and the pattern gain value calculated by the pattern gain calculator.

[0013] The present invention provides an apparatus for adjusting the saturation of a color image, comprising: a saturation calculator which calculates a saturation value for each of pixels of an input image; a mean saturation calculator which calculates a mean saturation value of the input image using saturation values calculated by the saturation calculator; a mean gain calculator which calculates a mean gain value based on the mean saturation value calculated by the mean saturation calculator; a color gain calculator which determines whether each of the pixels of the input image belongs to a predetermined color region and calculates a color gain value for a pixel depending on whether the pixel belongs to the predetermined color region; and a saturation adjustor which calculates a local gain value for each of the pixels using the mean gain value calculated by the mean gain calculator and the saturation values calculated by the saturation calculator and adaptively adjusts the saturation of each of the pixels of the input image using the local gain value and the color gain value calculated by the color gain calculator.

[0014] The present invention provides an apparatus for adjusting the saturation of a color image, comprising: a saturation calculator which calculates a saturation value for each of pixels of an input image; a mean saturation calculator which calculates a mean saturation value of the input image using saturation values calculated by the saturation calculator; a mean gain calculator which calculates a mean gain value based on the mean saturation value calculated by the mean saturation calculator; a pattern gain calculator which determines whether or not the input image is a predetermined pattern image and calculates a pattern gain value depending on whether the input image is determined as the predetermined pattern image; a color gain calculator which determines whether each of the pixels of the input image belongs to a predetermined color region and calculates a color gain value for a pixel depending on whether the pixel belongs to the predetermined color region; and a saturation adjustor which calculates a local gain value for each of the pixels using the mean gain value calculated by the mean gain calculator and the saturation values calculated by the saturation calculator and adaptively adjusts the saturation of each of the pixels of the input image using the local gain value, the pattern gain value calculated by the pattern gain calculator, and the color gain value calculated by the color gain calculator.

[0015] The present invention provides an apparatus for adjusting the saturation of a color image, comprising: a saturation calculator which calculates a saturation value for each of pixels of an input image; a peak saturation calculator which determines a peak saturation value of the input image using saturation values calculated by the saturation calculator; a peak gain calculator which calculates a peak gain value based on the peak saturation value determined by the peak saturation calculator; a mean saturation calculator which calculates a mean saturation value of the input image using the saturation values calculated by the saturation calculator; a mean gain calculator which calculates a mean gain value based on the mean saturation value calculated by the mean saturation calculator; and a saturation adjustor which calculates a local gain value for each of the pixels using the mean gain value calculated by the mean gain calculator and the saturation values calculated by the saturation calculator-and adaptively adjusts the saturation of each of the pixels of the input image using the local gain value and the peak gain value calculated by the peak gain calculator.

[0016] The present invention provides an apparatus for adjusting the saturation of a color image, comprising: a saturation calculator which calculates a saturation value for each of pixels of an input image; a peak saturation calculator which determines a peak saturation value of the input image using saturation values calculated by the saturation calculator; a peak gain calculator which calculates a peak gain value based on the peak saturation value determined by the peak saturation calculator; a mean saturation calculator which calculates a mean saturation value of the input image using the saturation values calculated by the saturation calculator; a mean gain calculator which calculates a mean gain value based on the mean saturation value calculated by the mean saturation calculator; a pattern gain calculator which determines whether or not the input image is a predetermined pattern image and calculates a pattern gain value depending on whether the input image is determined as the predetermined pattern image; and a saturation adjustor which calculates a local gain value for each of the pixels using the mean gain value calculated by the mean

gain calculator and the saturation values calculated by the saturation calculator and adaptively adjusts the saturation of each of the pixels of the input image using the local gain value, the peak gain value calculated by the peak gain calculator, and the pattern gain value calculated by the pattern gain calculator.

[0017] The present invention provides an apparatus for adjusting the saturation of a color image, comprising: a saturation calculator which calculates a saturation value for each of pixels of an input image; a peak saturation calculator which determines a peak saturation value of the input image using saturation values calculated by the saturation calculator; a peak gain calculator which calculates a peak gain value based on the peak saturation value determined by the peak saturation calculator; a mean saturation calculator which calculates a mean saturation value of the input image using the saturation values calculated by the saturation calculator; a mean gain calculator which calculates a mean gain value based on the mean saturation value calculated by the mean saturation calculator; a color gain calculator which determines whether each of the pixels of the input image belongs to a predetermined color region and calculates a color gain value for a pixel depending on whether the pixel belongs to the predetermined color region; and a saturation adjustor which calculates a local gain value for each of the pixels using the mean gain value calculated by the mean gain calculator and the saturation values calculated by the saturation calculator and adaptively adjusts the saturation of each of the pixels of the input image using the local gain value, the peak gain value calculated by the peak gain calculator, and the color gain value calculated by the color gain calculator.

[0018] The present invention also provides an apparatus for adjusting the saturation of a color image, comprising: a saturation calculator which calculates a saturation value for each of pixels of an input image; a peak saturation calculator which determines a peak saturation value of the input image using saturation values calculated by the saturation calculator; a peak gain calculator which calculates a peak gain value based on the peak saturation value determined by the peak saturation calculator; a mean saturation calculator which calculates a mean saturation value of the input image using the saturation values calculated by the saturation calculator; a mean gain calculator which calculates a mean gain value based on the mean saturation value calculated by the mean saturation calculator; a pattern gain calculator which determines whether or not the input image is a predetermined pattern image and calculates a pattern gain value depending on whether the input image is determined as the predetermined pattern image; a color gain calculator which determines whether each of the pixels of the input image belongs to a predetermined color region and calculates a color gain value for a pixel depending on whether the pixel belongs to the predetermined color region; and a saturation adjustor which calculates a local gain value for each of the pixels using the mean gain value calculated by the mean gain calculator and the saturation values calculated by the saturation calculator and adaptively adjusts the saturation of each of the pixels of the input image using the local gain value, the peak gain value calculated by the peak gain calculator, the pattern gain value calculated by the pattern gain calculator, and the color gain value calculated by the color gain calculator.

[0019] According to the present invention there is provided a method for adjusting the saturation of a color image corresponding to the apparatus claims 1 to 41.

[0020] In another aspect, the present invention provides a method for adjusting the saturation of a color image, comprising: (a) calculating a saturation value for each of pixels of an input image; (b) determining a peak saturation value of the input image using saturation values calculated in (a); (c) calculates a peak gain value based on the calculated peak saturation value calculated determined in (b); and (d) adaptively adjusting the saturation of the input image using the peak gain value calculated in (c).

[0021] An alternative method for adjusting the saturation of a color image according to the present invention comprises: (a) calculating a saturation value for each of pixels of an input image; (b) determining a peak saturation value of the input image using saturation values calculated in (a); (c) calculating a peak gain value base on the peak saturation value determined in (b); (c2) determining whether or not the input image is a predetermined pattern image and calculating a pattern gain value depending on whether the input image is determined as the predetermined pattern image; and (d) adaptively adjusting the saturation of the input image using the peak gain value calculated in (c) and the pattern gain value calculated in (c2).

[0022] The present invention also provides a method for adjusting the saturation of a color image, comprising: (a) calculating a saturation value for each of pixels of an input image; (b) determining a peak saturation value of the input image based on saturation values calculated in (a); (c) calculating a peak gain value based on the peak saturation value determined in (b); (c3) determining whether each of the pixels of the input image belongs to a predetermined color region and calculating a color gain value for a pixel depending on whether the pixel belongs to the predetermined color region; and (d) adaptively adjusting the saturation of the input image using the peak gain value calculated in (c) and the color gain value calculated in (c3).

[0023] The present invention also provides a method for adjusting the saturation of a color image, comprising: (a) calculating a saturation value for each of pixels of an input image; (b) determining a peak saturation value of the input image based on saturation values calculated in (a); (c) calculating a peak gain value based on the peak saturation value determined in (b); (c2) determining whether or not the input image is a predetermined pattern image and calculating a pattern gain value depending on whether the input image is determined as the predetermined pattern image;

(c3) determining whether each of the pixels of the input image belongs to a predetermined color region and calculating a color gain value for a pixel depending on whether the pixel belongs to the predetermined color region; and (d) adaptively adjusting the saturation of the input image using the peak gain value calculated in (c), the pattern gain value calculated in (c2), and the color gain value calculated in (c3).

[0024] The present invention provides a method for adjusting the saturation of a color image, comprising: (a) calculating a saturation value for each of pixels of an input image; (b1) determining a mean saturation value of the input image using saturation values calculated in (a); (c1) calculating a mean gain value based on the mean saturation value calculated in (b1); and (d) calculating a local gain value for each of the pixels using the mean gain value obtained in (c1) and the saturation values calculated in (a) and adaptively adjusting the saturation of each of the pixels of the input image using the local gain value.

[0025] The present invention also provides a method for adjusting the saturation of a color image, comprising: (a) calculating a saturation value for each of pixels of an input image; (b1) determining a mean saturation value of the input image using saturation values calculated in (a); (c1) calculating a mean gain value based on the mean saturation value calculated in (b1); (c2) determining whether or not the input image is a predetermined pattern image and calculating a pattern gain value depending on whether the input image is determined as the predetermined pattern image; and (d) calculating a local gain value for each of the pixels using the mean gain value obtained in (c1) and the saturation values calculated in (a) and adaptively adjusting the saturation of each of the pixels of the input image using the local gain value and the pattern gain value calculated in (c2).

[0026] The present invention also provides a method for adjusting the saturation of a color image, comprising: (a) calculating a saturation value for each of pixels of an input image; (b1) determining a mean saturation value of the input image using saturation values calculated in (a); (c1) calculating a mean gain value based on the mean saturation value calculated in (b1); (c3) determining whether each of the pixels of the input image belongs to a predetermined color region and calculating a color gain value for a pixel depending on whether the pixel belongs to the predetermined color region; and (d) calculating a local gain value for each of the pixels using the mean gain value obtained in (c1) and the saturation values calculated in (a) and adaptively adjusting the saturation of each of the pixels of the input image using the local gain value and the color gain value calculated in (c3).

[0027] Alternatively, the present invention provides a method for adjusting the saturation of a color image, comprising: (a) calculating a saturation value for each of pixels of an input image; (b1) calculating a mean saturation value of the input image using saturation values calculated in (a); (c1) calculating a mean gain value based on the mean saturation value calculated in (b1); (c2) determining whether or not the input image is a predetermined pattern image and calculating a pattern gain value depending on whether the input image is determined as the predetermined pattern image; (c3) determining whether each of the pixels of the input image belongs to a predetermined color region and calculating a color gain value for a pixel depending on whether the pixel belongs to the predetermined color region; and (d) calculating a local gain value for each of the pixels using the mean gain value calculated in (c1) and the saturation values calculated in (a) and adaptively adjusting the saturation of each of the pixels of the input image using the local gain value, the pattern gain value calculated in (c2), and the color gain value calculated in (c3).

[0028] The present invention provides a method for adjusting the saturation of a color image, comprising: (a) calculating a saturation value for each of pixels of an input image; (b) determining a peak saturation value of the input image based on saturation values calculated in (a); (c) calculating a peak gain value based on the peak saturation value determined in (b); (b1) calculating a mean saturation value of the input image using the saturation values calculated in (a); (c1) calculating a mean gain value based on the mean saturation value calculated in (b1); and (d) calculating a local gain value for each of the pixels using the mean gain value calculated in (c1) and the saturation values calculated in (a) and adaptively adjusting the saturation of each of the pixels of the input image using the local gain value and the peak gain value calculated in (c).

[0029] The present invention provides a method for adjusting the saturation of a color image, comprising: (a) calculating a saturation value for each of pixels of an input image; (b) determining a peak saturation value of the input image based on saturation values calculated in (a); (c) calculating a peak gain value based on the peak saturation value determined in (b); (b1) calculating a mean saturation value of the input image using the saturation values calculated in (a); (c1) calculating a mean gain value based on the mean saturation value calculated in (b1); (c2) determining whether or not the input image is a predetermined pattern image and calculating a pattern gain value depending on whether the input image is determined as the predetermined pattern image; and (d) calculating a local gain value for each of the pixels using the mean gain value calculated in (c1) and the saturation values calculated in (a) and adaptively adjusting the saturation of each of the pixels of the input image using the local gain value, the peak gain value calculated in (c), and the pattern gain value calculated in (c2).

[0030] The present invention provides a method for adjusting the saturation of a color image, comprising: (a) calculating a saturation value for each of pixels of an input image; (b) determining a peak saturation value of the input image based on saturation values calculated in (a); (c) calculating a peak gain value based on the peak saturation value determined in (b); (b1) calculating a mean saturation value of the input image using the saturation values calculated

in (a); (c1) calculating a mean gain value based on the mean saturation value calculated in (b1); (c3) determining whether each of the pixels of the input image belongs to a predetermined color region and calculating a color gain value for a pixel depending on whether the pixel belong to the predetermined color region; and (d) calculating a local gain value for each of the pixels using the mean gain value calculated in (c1) and the saturation values calculated in (a) and adaptively adjusting the saturation of each of the pixels of the input image using the local gain value, the peak gain value calculated in (c), and the color gain value calculated in (c3).

[0031] Alternatively, the present invention provides a method for adjusting the saturation of a color image, comprising: (a) calculating a saturation value for each of pixels of an input image; (b) determining a peak saturation value of the input image using saturation values calculated in (a); (c) calculating a peak gain value based on the peak saturation value determined in (b); (b1) calculating a mean saturation value of the input image using the saturation values calculated in (a); (c1) calculating a mean gain value based on the mean saturation value calculated in (b1); (c2) determining whether or not the input image is a predetermined pattern image and calculating a pattern gain value depending on whether the input image is determined as the predetermined pattern image; (c3) determining whether each of the pixels of the input image belongs to a predetermined color region and calculating a color gain value for a pixel depending on whether the pixel belongs to the predetermined color region; and (d) calculating a local gain value for each of the pixels using the mean gain value calculated in (c1) and the saturation values calculated in (a) and adaptively adjusting the saturation of each of the pixels of the input image using the local gain value, the peak gain value calculated in (c), the pattern gain value calculated in (c2), and the color gain value calculated in (c3).

[0032] The above objects and advantages of the present invention will become more apparent by describing in detail exemplary embodiments thereof with reference to the attached drawings in which:

FIG. 1 shows a saturation adjusting apparatus according to an embodiment of the present invention;

FIG. 2 shows a saturation histogram according to the present invention;

FIG. 3 shows a gain function for a peak gain value according to the present invention;

FIG. 4 shows a pattern gain function for a pattern gain value according to the present invention;

FIG. 5 shows gain functions for a color gain value according to the present invention;

FIG. 6 shows other gain functions for the color gain value according to the present invention;

FIG. 7 shows a saturation adjusting apparatus according to another embodiment of the present invention;

FIG. 8 shows gain functions for a mean gain value and a local gain value according to the present invention; and

FIG. 9 shows a saturation adjusting apparatus according to still another embodiment of the present invention.

[0033] Embodiments of the present invention will be described in detail with reference to the appended drawings.

[0034] A saturation adjusting apparatus according to an embodiment of the present invention is shown in FIG. 1. Referring to FIG. 1, the saturation adjusting apparatus includes a frame memory 110, a saturation calculator 120, a histogram calculator 130, a peak saturation calculator 140, a peak gain calculator 150, a final gain calculator 160, and a saturation adjustor 170.

[0035] The frame memory 110 stores an input image signal. The saturation calculator 120 calculates a saturation value $S(x,y)$ for each of pixels stored in the frame memory 110. The histogram calculator 130 calculates a saturation histogram for all pixels of the image or a local window region from the saturation value $S(x,y)$ of each of the pixels calculated by the saturation calculator 120. The peak saturation calculator 140 determines a peak saturation value s_{peak} from the histogram calculated by the histogram calculator 130, and the peak gain calculator 150 calculates a peak gain value g_{peak} from the peak saturation value s_{peak}. A gain value g to be applied to pixels is determined by using the peak gain value g_{peak}, a selectively applicable system gain value value g_{enh}, and a user gain value g_{user} which is adjusted by the user. An input pixel signal $YCbCr(x,y)$ is processed with the gain value g to obtain a saturation-adjusted final output signal $YCbCr_{enh}(x,y)$.

[0036] An embodiment of the present invention will be described below with reference to FIGS. 1 through 3.

[0037] After the input image signal is stored in the frame memory 110, the saturation calculator 120 calculates a saturation value $S(x,y)$ for each of the pixels input from the frame memory 110. In the embodiment, the saturation value $S(x,y)$ is calculated using equations 1 and 2 below, wherein equation 1 is applied to convert the pixel signal YCbCr into an RGB signal to comply with the specification of ITU-R BT.709-4, and equation 2 is applied to the RGB signal.

$$(R,G,B) = (Y+a\cdot Cr, Y+b\cdot Cr+c\cdot Cb, Y+d\cdot Cb) \quad (1)$$

where a,b,c and d are conversion coefficients.

$$S = \frac{Max[R,G,B] - Min[R,G,B]}{Max[R,G,B] + Min[R,G,B]} \quad or \quad S = \frac{Max[R,G,B] - Min[R,G,B]}{Max[R,G,B]} \quad \ldots(2)$$

where S is a normalized saturation value between 0 and 1. When hardware is designed to set the normalized saturation value S in an integer format of [0, 100], a histogram as shown in FIG. 2 can be obtained by accumulating the saturation values of all pixels. If *Max [R,G,B]* for the normalized saturation value S has a very small or very large value, S is not accumulated considering image noise.

[0038] The peak saturation calculator 140 determines a saturation value of the pixels corresponding to 0.5% of the total number of pixels from the pixel having the largest saturation value, as the peak saturation value s_{peak}, from the histogram calculated by the histogram calculator 130, as shown in FIG. 2. Here, the limit of 0.5% was determined considering noises of the input image, and can be varied depending on noise levels.

[0039] The peak gain calculator 150 determines the peak gain value g_{peak} using the peak saturation value s_{peak} determined by the peak saturation calculator 140 and a gain function of FIG. 3. According to the gain function of FIG. 3, a peak gain value g_{peak} is 0 for a peak saturation value s_{peak} of 1, linearly increases as the peak saturation value s_{peak} decreases from 1 to 0.5, and gradually linearly attenuates and converges to zero as the peak saturation value s_{peak} decreases from 0.5 to 0. Therefore, the gain function of FIG. 3 is effective to reduce an extremely large gain for a gray input image.

[0040] The final gain calculator 160 calculates the final gain g for the input image using the peak gain value g_{peak} calculated by the peak gain calculator 150, the system gain value g_{enh}, and the user gain value g_{user}, as expressed in equation 3:

$$g = g_{user} \cdot (1+g_{enh} \cdot g_{peak}) \quad (3)$$

[0041] The system gain value g_{enh} controls degrees of the color image enhancement. When the system gain value g_{enh} is 0, there is no image enhancement effect. The image quality is greatly enhanced with increasing system gain value g_{enh} more than 1. A general system gain value default is a value between 0.5 and 1 and is determined through a visual test using a number of observers.

[0042] The user gain value g_{user} is similar to a value set by the user on an existing color TV receiver using a saturation adjuster, which is usually indicated by a "color button". When the user gain value g_{user} is 0, a gray image is displayed. The saturation of the image is increased with increasing user gain value g_{user} more than 1. A general user gain value default is 1 for standard color image display.

[0043] The saturation adjustor 170 outputs a saturation-adjusted signal $YCbCr_{enh}(x,y)$ by applying the final gain g calculated by the final gain calculator 160 to the original color signals *Cb* and *Cr* of each of the pixels, as expressed in equation 4:

$$(Y,Cb,Cr)_{enh}(x,y) = (Y(x,y),\ g\cdot Cb(x,y),\ g\cdot Cr(x,y)) \quad (4)$$

[0044] Through the saturation adjustment for all pixels of one frame in the above-described manner, color enhancement and equalization for the frame are complete.

[0045] Although the gain function of FIG. 3 is used in the embodiment, a variety of gain functions having no discontinuity can be applied if necessary.

[0046] Another embodiment of the present invention will be described below with reference to FIGS. 1 and 4. In this embodiment, the frame memory 110, the saturation calculator 120, the histogram calculator 130, the peak saturation

calculator 140, and the peak gain calculator 150 described in the previous embodiment provide the same functions as in the previous embodiment, and thus detailed descriptions thereon will be omitted here.

[0047] The peak saturation calculator 140 determines the peak saturation value s_{peak} from the histogram formed by the histogram calculator 130, as shown in FIG. 2, and the peak gain calculator 150 calculates the peak gain value g_{peak} using the gain function of FIG. 3.

[0048] A pattern gain calculator 180 detects a test pattern image or a monotone image, for example, an image of a bird flying in the sky or an image of sunset, and calculates a pattern gain value g_p for the test pattern image or monotone image. Compared with a general natural image, apparently from their histogram, the test pattern image and the monotone image have relatively high frequency components. In consideration of this characteristic of the test pattern image and monotone image, the absolute value of a pixel count difference between adjacent saturation regions is calculated for the entire saturation histogram (i=1, ..., N-1), and an average of the absolute values for all saturation regions is calculated as a P value, as expressed in equation 5:

$$P = \frac{1}{N}\sum_{i=1}^{N-1} |H(i) - H(i+1)| \qquad \ldots(5)$$

where *H(i)* denotes the number of pixels in a saturation region *i*. The pattern gain value g_p is calculated using a pattern gain function of FIG. 4 and the P value calculated by using equation 5. In the pattern gain function of FIG. 4, Th_{Low} and Th_{High} vary depending on the normalization of the maximum count in the histogram. When the P value is smaller than Th_{Low}, the input image corresponds to a general natural image (having a continuous histogram). When the P value is greater than Th_{High} (having a discrete histogram), the input image corresponds to a test pattern image. Accordingly, when the input image has a P value corresponding to a general natural image, the pattern gain value g_p is set to 1. When the input image has a P value corresponding to a test pattern, the pattern gain value g_p is set to 0 to bypass the saturation adjustment for the original input image.

[0049] When the input image has a P value between Th_{Low} and Th_{High}, the input image corresponds to a monotone image. In this case, an excess increase in the saturation of the monotone image degrades picture quality. Accordingly, the pattern gain value g_p for such a monochrome image is reduced inversely with respect to the P value.

[0050] This pattern detection algorithm is resistant to noise and is simple in process, and thus can be practically applied with reliability.

[0051] The final gain calculator 160 calculates a final gain g for the input image using the peak gain value g_{peak} calculated by the peak gain calculator 150, the pattern gain value g_p calculated by the pattern gain calculator 180, the system gain value g_{enh}, and the user gain value g_{user}, as expressed in equation 6:

$$g = g_{user} \cdot (1 + g_{enh} \cdot g_p \cdot g_{peak}) \qquad (6)$$

[0052] The saturation adjustor 170 outputs a saturation-adjusted signal $YCbCr_{enh}(x,y)$ by applying the final gain g calculated by the final gain calculator 160 to the original color signals *Cb* and *Cr* of each of the pixels, which is calculated using equation 4 above.

[0053] Through the saturation adjustment for all pixels of one frame in the above-described manner, color enhancement and equalization for the frame are complete.

[0054] Although the pattern gain function of FIG. 4 is used in the above embodiment, a variety of pattern gain functions having no discontinuity can be applied if necessary.

[0055] Another embodiment of the present invention will be described below with reference to FIGS. 1, 5, and 6. In this embodiment, the frame memory 110, the saturation calculator 120, the histogram calculator 130, the peak saturation calculator 140, and the peak gain calculator 150 shown in FIG. 1 and described in the previous embodiment provide the same functions as in the previous embodiment, and thus detailed descriptions thereon will be omitted here.

[0056] A color gain calculator 190 calculates a color gain value $g_{skin}(x,y)$ depending on whether each pixel of the input image belongs to a skin color region. To determine whether a pixel value input to the color gain calculator 190 belongs to the skin color region, it is necessary to track the position of the skin color region in the YCbCr color space.

[0057] In the present invention, a method using an ellipsoidal gain function and a logic "AND" combination method of gain functions for Y, Cb, Cr signals are suggested to determine whether the input pixel belongs to the skin color region. The two methods can be applied to any color space, for example, RGB, YUV, CIELAB, and CIELUV spaces.

[0058] In the method using a 3-D ellipsoidal gain function, as shown in (a) of FIG. 5, a mean color value (Ym, Cbm, Crm) of the skin color region is determined as the center coordinate of the ellipsoid, and race- or system-dependent

skin color variations of three axes of the ellipsoidal equation are determined as radii (Yr, Cbr, Crr) of the ellipsoid, which is expressed in equation 7 below:

$$f(Y, Cb, Cr) = \left(\frac{Y - Ym}{Yr}\right)^2 + \left(\frac{Cb - Cbm}{Cbr}\right)^2 + \left(\frac{Cr - Crm}{Crr}\right)^2 \quad \ldots(7)$$

[0059] The color gain value $g_{skin}(x,y)$ for a given pixel is derived using $f(Y, Cb, Cr)$ calculated using equation 7 above. When $f(Y, Cb, Cr)$ for the $YCbCr$ value of the given pixel is smaller than r, the pixel is determined to belong to the skin color region. Especially, a region of the ellipsoid with $f(Y, Cb, Cr) = r$ is called "kernel gamut", as shown in (b) of FIG. 5. When $f(Y, Cb, Cr)$ for an input pixel is in the kernel gamut, the input pixel is determined to belong to the skin color region, and the color gain value $g_{skin}(x,y)$ is set to 0.

[0060] When $f(Y, Cb, Cr)$ for an input pixel is greater than 1, the input pixel is determined not to belong to the skin color region. Especially, a region of the ellipsoid with $f(Y, Cb, Cr) = r$ is called "boudary gamut", as shown in (b) of FIG. 5. For a pixel which is beyond the boundary gamut, the color gain value $g_{skin}(x,y)$ is set to 1.

[0061] When $f(Y, Cb, Cr)$ for an input pixel has a value between the kernel gamut and the boundary gamut, the color gain value $g_{skin}(x,y)$ for the input pixel is set to $(f(Y, Cb, Cr) - r)/(1-r)$, based on the linear graph between r and 1 providing continuity between the kernel gamut and the boundary gamut, as shown in (c) of FIG. 5, to consider skin color variations in a source image and to ensure continuity of color in the kernel gamut and the boundary gamut.

[0062] In the other method to determine whether the input image belongs to the skin color region, a skin color gain function for each of the Y, Cb, and Cr signals is defined, as shown in (a), (b), and (c) of FIG. 6, and the three gain functions are combined by logic AND operation, which are expressed in equation 8 below:

$$g_{skin}(Y,Cb,Cr) = 1 - [g_{skin}(Y) \cdot g_{skin}(Cb) \cdot g_{skin}(Cr)] \quad (8)$$

[0063] As an example, (d) of FIG. 6 shows the skin color gain function $g_{skin}(Y,Cb,Cr)$ for Y=0.5 in the 3-D YCbCr color coordinate system.

[0064] The color gain calculator 190 calculates the color gain value $g_{skin}(x,y)$ varying according to the color coordinate of the input pixel by using one of the above-described methods.

[0065] The final gain calculator 190 calculates a final gain $g(x,y)$ for the input image, which varies according to the color coordinate and saturation of the pixels, using the peak gain value g_{peak} calculated by the peak gain calculator 150, the color gain value $g_{skin}(x,y)$ calculated by the color gain calculator 190, the system gain value g_{enh}, and the user gain value g_{user}, as expressed in equation 9:

$$g(x,y) = g_{user} \cdot (1 + g_{enh} \cdot g_{skin}(x,y) \cdot g_{peak}) \quad (9)$$

[0066] The saturation adjustor 170 outputs a saturation-adjusted signal $YCbCr_{enh}(x,y)$ by applying the final gain $g(x,y)$ calculated by the final gain calculator 160 to the original color signals Cb and Cr of each of the pixels, as expressed in equation 10 below:

$$(Y,Cb,Cr)_{enh}(x,y) = (Y(x,y),\ g(x,y) \cdot Cb(x,y),\ g(x,y) \cdot Cr(x,y)) \quad (10)$$

[0067] Through the saturation adjustment for all pixels of one frame in the above-described manner, color enhancement and equalization for the frame are complete.

[0068] Another embodiment of the present invention will be described with reference to FIGS. 1 through 6. In this embodiment, the frame memory 110, the saturation calculator 120, the histogram calculator 130, the peak saturation calculator 140, the peak gain calculator 150, the pattern gain calculator 180, and the color gain calculator 190 shown in FIG. 1 and described in the previous embodiment provide the same functions as in the previous embodiment, and thus detailed descriptions thereon will be omitted here.

[0069] The final gain calculator 160 calculates a final gain $g(x,y)$ for the input image, which varies according to the color coordinate and saturation of the pixels, using the peak gain value g_{peak} calculated by the peak gain calculator 150, the color gain value $g_{skin}(x,y)$ calculated by the color gain calculator 190, the pattern gain value g_p calculated by

the pattern gain calculator 180, the system gain value g_{enh}, and the user gain value g_{user}, as expressed in equation 11:

$$g(x,y) = g_{user} \cdot (1 + g_{enh} \cdot g_{skin}(x,y) \cdot g_p \cdot g_{peak}) \tag{11}$$

[0070] The saturation adjustor 170 outputs a saturation-adjusted signal $YCbCr_{enh}(x,y)$ by applying the final gain $g(x,y)$ calculated by the final gain calculator 160 to the original color signals Cb and Cr of each of the pixels, as expressed in equation 10 above.

[0071] Another embodiment of the present invention will be described with reference to FIGS. 2, 7, and 8. A frame memory 710, a saturation calcutor 720, and a histogram calculator 730 shown in FIG. 7 provide the same functions as in the previous embodiments described with reference to FIG. 1, and thus detailed descriptions thereon will be omitted here.

[0072] A mean saturation calculator 742 calculates a mean saturation value s_{mean} from the histogram of FIG. 2 obtained by the histogram calculator 730.

[0073] A mean gain calculator 752 calculates a mean gain value g_{mean} using the mean saturation value s_{mean} determined by the mean saturation calculator 742 and a gain function of (a) in FIG. 8. According to the gain function (a) of FIG. 8, when the mean saturation value s_{mean} of the input image is greater than or equal to 0.5, the mean gain value g_{mean} is set to 0 to bypass processing on the original image. The mean gain value g_{mean} is linearly increased as the mean saturation value s_{mean} decreases from 0.5 to 0.25. The mean gain value g_{mean} is reduced for a gray image as the mean saturation value s_{mean} approaches 0 from 0.25.

[0074] The final gain calculator 760 calculates a local gain value $g_{local}(x,y)$ for each pixel using the gain function (b) of FIG. 8 obtained from the mean gain value g_{mean} and the saturation value $S(x,y)$ for the corresponding pixel calculated by the saturation calculator 720. According to the gain function (b) of FIG. 8, the maximum value at the inflection point is equal to the mean gain value g_{mean} calculated by the mean gain calculator 752. The gain value $g_{local}(x,y)$ is reduced for a gray image as the saturation value $S(x,y)$ of the pixel approaches 0 from the inflection point (r.p).

[0075] As is apparent from the gain function (b) of FIG. 8, the gain value $g_{local}(x,y)$ for each of the pixels was determined to be smaller for a pixel having a greater saturation value $S(x,y)$, thereby reducing the need for gamut mapping in a conventional image process, which results in an unnatural image having abrupt color variations.

[0076] For a rapid calculation of the gain value $g_{local}(x,y)$ for each of the pixels, it is preferable to use an additional memory for storing the data calculated by the saturation calculator 720 as long as the system size is large enough for the amount of memory.

[0077] The final gain calculator 760 calculates a final gain $g(x,y)$ for the input image, which varies according to the color coordinate and saturation of the pixels, using the gain value $g_{local}(x,y)$ calculated by the final gain calculator 760, the system gain value g_{enh}, and the user gain value g_{user}, as expressed in equation 12:

$$g(x,y) = g_{user} \cdot (1 + g_{enh} \cdot g_{local}(x,y)) \tag{12}$$

[0078] The saturation adjustor 770 outputs a saturation-adjusted signal $YCbCr_{enh}(x,y)$ by applying the final gain $g(x,y)$ calculated by the final gain calculator 160 to the original color signals Cb and Cr of each of the pixels, as expressed in equation 10 above.

[0079] Although the gain functions (a) and (b) of FIG. 8 are used in the embodiment, a variety of gain functions having no discontinuity can be applied if necessary.

[0080] Another embodiment of the present invention will be described below with reference to FIGS. 4, 7, and 8. In this embodiment, the frame memory 710, the saturation calculator 720, the histogram calculator 730, the mean saturation calculator 742, the mean gain calculator 752, and the pattern gain calculator 780 provide the same functions as in the previous embodiments described with reference to FIGS. 1 and 7, and thus detailed descriptions thereon will be omitted here.

[0081] The final gain calculator 760 calculates a final gain $g(x,y)$ for the input image, which varies according to the color coordinate and saturation of the pixels, using the gain value $g_{local}(x,y)$ obtained with the mean gain value g_{mean} calculated by the mean gain calculator 752, the pattern gain value g_p calculated by the gain pattern calculator 780, the system gain value g_{enh}, and the user gain value g_{user}, as expressed in equation 13:

$$g(x,y) = g_{user} \cdot (1+g_{enh} \cdot g_p \cdot g_{local}(x,y)) \tag{13}$$

[0082] The saturation adjustor 770 outputs a saturation-adjusted signal $YCbCr_{enh}(x,y)$ by applying the final gain g

(x,y) calculated by the final gain calculator 160 to the original color signals *Cb* and *Cr* of each of the pixels, as expressed in equation 10 above.

[0083] Another embodiment of the present invention will be described below with reference to FIGS. 5, 6, 7, and 8. In this embodiment, the frame memory 710, the saturation calculator 720, the histogram calculator 730, the mean saturation calculator 742, the mean gain calculator 752, and the color gain calculator 790 provide the same functions as those in the previous embodiments described with reference to FIGS. 1 and 7, and thus detailed descriptions thereon will be omitted here.

[0084] The final gain calculator 760 calculates a final gain $g(x,y)$ for the input image, which varies according to the color coordinate and saturation of the pixels, using the gain value $g_{local}(x,y)$ obtained with the mean gain value g_{mean} calculated by the mean gain calculator 752, the color gain value $g_{skin}(x,y)$ calculated by the color gain calculator 790, the system gain value g_{enh}, and the user gain value g_{user}, as expressed in equation 14:

$$g(x,y) = g_{user} \cdot (1+g_{enh} \cdot g_{skin}(x,y) \cdot g_{local}(x,y)) \tag{14}$$

[0085] The saturation adjustor 770 outputs a saturation-adjusted signal $YCbCr_{enh}(x,y)$ by applying the final gain $g(x,y)$ calculated by the final gain calculator 760 to the original color signals *Cb* and *Cr* of each of the pixels, as expressed in equation 10 above.

[0086] Another embodiment of the present invention will be described below with reference to FIG. 7. In this embodiment, the frame memory 710, the saturation calculator 720, the histogram calculator 730, the mean saturation calculator 742, the mean gain calculator 752, the mean gain calculator 780, and the color gain calculator 790 provide the same functions as in the previous embodiments, and thus detailed descriptions thereon will be omitted here.

[0087] The final gain calculator 760 calculates a final gain $g(x,y)$ for the input image, which varies according to the color coordinate and saturation of the pixel, using the gain value $g_{local}(x,y)$ obtained with the mean gain value g_{mean} calculated by the mean gain calculator 752, the pattern gain value g_p calculated by the pattern gain calculator 780, the color gain value $g_{skin}(x,y)$ calculated by the color gain calculator 790, the system gain value g_{enh}, and the user gain value g_{user}, as expressed in equation 15:

$$g(x,y) = g_{user} \cdot (1 + g_{enh} \cdot g_{skin}(x,y) \cdot g_p \cdot g_{local}(x,y)) \tag{15}$$

[0088] The saturation adjustor 770 outputs a saturation-adjusted signal $YCbCr_{enh}(x,y)$ by applying the final gain $g(x,y)$ calculated by the final gain calculator 760 to the original color signals *Cb* and *Cr* of each of the pixels, as expressed in equation 10 above.

[0089] FIG. 9 shows a saturation adjusting apparatus according to another embodiment of the present invention. A frame memory 910, a saturation calculator 920, a histogram calculator 930, a peak saturation calculator 940, a peak gain calculator 950, a mean saturation calculator 942, ad a mean gain calculator 952 provide the same function as those in the previous embodiments described with reference to FIGS. 1 and 7, and thus detailed descriptions thereon will be omitted here.

[0090] The final gain calculator 960 calculates a final gain $g(x,y)$ for the input image, which varies according to the color coordinate and saturation of the pixels, using the peak gain value g_{peak} determined by the peak gain calculator 950, the local gain value $g_{local}(x,y)$ obtained with the mean gain value g_{mean} calculated by the mean gain calculator 952, the system gain value g_{enh}, and the user gain value g_{user}, as expressed in equation 16:

$$g(x,y) = g_{user} \cdot (1+g_{enh} \cdot (g_{peak} + g_{local}(x,y))) \tag{16}$$

[0091] The saturation adjustor 970 outputs a saturation-adjusted signal $YCbCr_{enh}(x,y)$ by applying the final gain $g(x,y)$ calculated by the final gain calculator 760 to the original color signals *Cb* and *Cr* of each of the pixels, as expressed in equation 10 above.

[0092] Another embodiment of the present invention will be described below with reference to FIG. 9. In this embodiment, the frame memory 910, the saturation calculator 920, the histogram calculator 930, the peak saturation calculator 940, the peak gain calculator 950, the mean saturation calculator 942, the mean gain calculator 952, and the pattern gain calculator 980 provide the same functions as in the previous embodiments described with reference to FIGS. 1 and 7.

[0093] The final gain calculator 960 calculates a final gain $g(x,y)$ for the input image, which varies according to the color coordinate and saturation of the pixels, using the peak gain value g_{peak} determined by the peak gain calculator

950, the local gain value $g_{local}(x,y)$ obtained with the mean gain value g_{mean} calculated by the mean gain calculator 952, the gain pattern value g_p calculated by the pattern gain calculator 980, the system gain value g_{enh}, and the user gain value g_{user}, as expressed in equation 17:

$$g(x,y) = g_{user} \cdot (1+g_{enh} \cdot g_p \cdot (g_{peak} + g_{local}(x,y))) \tag{17}$$

[0094] The saturation adjustor 970 outputs a saturation-adjusted signal $YCbCr_{enh}(x,y)$ by applying the final gain $g(x,y)$ calculated by the final gain calculator 760 to the original color signals *Cb* and *Cr* of each of the pixels, as expressed in equation 10 above.

[0095] Another embodiment of the present invention will be described below with reference to FIG. 9. In this embodiment, the frame memory 910, the saturation calculator 920, the histogram calculator 930, the peak saturation calculator 940, the peak gain calculator 950, the mean saturation calculator 942, the average gain calculator 952, and the color gain calculator 990 provide the same functions as in the previous embodiments described with reference to FIGS. 1 and 7.

[0096] The final gain calculator 960 calculates a final gain $g(x,y)$ for the input image, which varies according to the color coordinate and saturation of the pixels, using the peak gain value g_{peak} determined by the peak gain calculator 950, the local gain value $g_{local}(x,y)$ obtained with the mean gain value g_{mean} calculated by the mean gain calculator 952, the color gain value $g_{skin}(x,y)$ calculated by the color gain calculator 990, the system gain value g_{enh}, and the user gain value g_{user}, as expressed in equation 18:

$$g(x,y) = g_{user} \cdot (1+g_{enh} \cdot g_{skin}(x,y) \cdot (g_{peak} + g_{local}(x,y))) \tag{18}$$

[0097] The saturation adjustor 970 outputs a saturation-adjusted signal $YCbCr_{enh}(x,y)$ by applying the final gain $g(x,y)$ calculated by the final gain calculator 760 to the original color signals *Cb* and *Cr* of each of the pixels, as expressed in equation 10 above.

[0098] Another embodiment of the present invention will be described below with reference to FIG. 9. In this embodiment, the frame memory 910, the saturation calculator 920, the histogram calculator 930, the peak saturation calculator 940, the peak gain calculator 950, the mean saturation calculator 942, the mean gain calculator 952, the pattern gain calculator 980, and the color gain calculator 990 provide the same functions as in the previous embodiments described with reference to FIGS. 1 and 7, and thus detailed descriptions thereon will be omitted here.

[0099] The final gain calculator 960 calculates a final gain $g(x,y)$ for the input image, which varies according to the color coordinate and saturation of the pixels, using the peak gain value g_{peak} determined by the peak gain calculator 950, the local gain value $g_{local}(x,y)$ obtained with the mean gain value g_{mean} calculated by the mean gain calculator 952, the color gain value $g_{skin}(x,y)$ calculated by the color gain calculator 990, the pattern gain value g_p calculated by the pattern gain calculator 980, the system gain value g_{enh}, and the user gain value g_{user}, as expressed in equation 19:

$$g(x,y) = g_{user} \cdot (1+g_{enh} \cdot g_p \cdot g_{skin}(x,y) \cdot (g_{peak} + g_{local}(x,y))) \tag{19}$$

[0100] The saturation adjustor 970 outputs a saturation-adjusted signal $YCbCr_{enh}(x,y)$ by applying the final gain $g(x,y)$ calculated by the final gain calculator 760 to the original color signals Cb and *Cr* of each of the pixels, as expressed in equation 10 above.

[0101] As described above, according to the present invention, the saturation of an output image can be adaptively adjusted using information extracted from an input image, thereby enhancing the quality of the image.

[0102] In particular, peak saturation and mean saturation values of the input image are detected and used to correct for the saturation of the input image. When the input image is a quality, high-saturation image, processing on the input image is bypassed. When the input image has a low saturation value, the saturation of, for example, the entire image or a particular color region of the image can be increased for quality enhancement. Also, saturation variations between frames of a moving picture displayed on hardware, which may occur during data transmission, or between TV channels, can be automatically equalized to maintain a constant saturation level.

[0103] In addition, the saturation adjusting apparatus according to the present detects a test pattern image to bypass saturation adjustment on the test pattern image invention, and thus to control the quality of the test pattern image displayed on a display apparatus. It is also determined weather an input pixel belongs to a skin color region, and the saturation adjustment is performed only on the other color region, such as a background image, to suppress an excess increase in the saturation of the skin color.

[0104] A gain value obtained from the input image information is applied only to the color signals *Cb* and *Cr* of the image to selectively adjust the saturation of the input image while the brightness of the input image is maintained. Since the gain value is calculated in consideration of the saturation value of each pixel, an unnecessary gamut-mappint block can be eliminated to prevent saturation distortion and to construct simple system hardware. A gain value for a gray image is adaptively reduced to maintain gray-balance.

Claims

1. An apparatus for adjusting the saturation of a color image, comprising:

    a saturation calculator (120, 920) which calculates a saturation value for each of pixels of an input image;
    a peak saturation calculator (140,940) which determines a peak saturation value of the input image using saturation values calculated by the saturation calculator;
    a peak gain calculator (150, 950) which calculates a peak gain value based on the peak saturation value determined by the peak saturation calculator; and
    a saturation adjustor (170, 970) which adaptively adjusts the saturation of the input image using the peak gain value calculated by the peak gain calculator.

2. The apparatus of claim 1, further comprising a histogram calculator (130, 930) which calculates a saturation histogram of the input image using the saturation values calculated by the saturation calculator, wherein the peak saturation calculator determines the peak saturation value from the saturation histogram calculated by the histogram calculator.

3. The apparatus of claim 1 or 2, wherein the saturation calculator converts an input image signal into an RGB signal and calculates the saturation for each of the pixels as a ratio of the difference between maximum and minimum values of the RGB signal to the sum of the maximum and minimum values of the RGB signal.

4. The apparatus of claim 3, wherein the input image signal input to the saturation calculator is one of YCbCr, YUV, and YIQ signals.

5. The apparatus of claim 3 or 4, wherein when the maximum value of the RGB signal for the input image signal processed by the saturation calculator is less than a predetermined value or is greater than or equal to another predetermined value, the maximum value of the input image signal is not accumulated to calculate the saturation histogram.

6. The apparatus of any of claims 1 to 5, further comprising:

    a mean saturation calculator (942) which calculates a mean saturation value of the input image using the saturation values calculated by the saturation calculator; and
    a mean gain calculator (952) which calculates a mean gain value based on the mean saturation value calculated by the mean saturation calculator,

    wherein the saturation adjustor calculates a local gain value for each of the pixels using the mean gain value calculated by the mean gain calculator and the saturation values calculated by the saturation calculator and adaptively adjusts the saturation of each of the pixels of the input image using the local gain value and the peak gain value.

7. The apparatus of any of claims 1 to 6, wherein the peak gain calculator calculates a peak gain value for a peak saturation value smaller than or equal to a first saturation value and for a peak gain value greater than or equal to a second saturation value, wherein the second saturation value is greater than the first saturation value, to be smaller than that for a peak saturation value between the first and second saturation values.

8. The apparatus of any of claims 1 to 7, wherein the peak saturation calculator determines a saturation value of the pixels corresponding to a predetermined percentage of the total number of pixels from the pixel having the largest saturation value, as the peak saturation value.

9. The apparatus of any of claims 1 to 8, wherein the saturation adjustor adaptively adjusts the saturation of the input

image further in consideration of at least one of a system gain value and a user gain value.

10. The apparatus of any of claims 1 to 9, further comprising:

a pattern gain calculator (180, 980) which determines whether or not the input image is a predetermined pattern image and calculates a pattern gain value for the predetermined pattern image depending on whether the input image is determined as the predetermined pattern image,

wherein the saturation adjustor adjusts the saturation of the input image using additionally the pattern gain value calculated by the pattern gain calculator.

11. The apparatus of claim 10, wherein the predetermined pattern image is a test pattern image.

12. The apparatus of claim 10 or 11, wherein the pattern gain calculator calculates the absolute value of a pixel count difference between adjacent saturation regions and an average of the calculated absolute values for all saturation regions of the input image and calculates the pattern gain value using the calculated average of the absolute values.

13. The apparatus of any of claims 1 to 12, further comprising:

a color gain calculator (190, 990) which determines whether each of the pixels of the input image belongs to a predetermined color region and calculates a color gain value for a pixel depending on whether the pixel belongs to the predetermined color region,

wherein the saturation adjustor adaptively adjusts the saturation for each of the pixels of the input image using the peak gain value calculated by the peak gain calculator and the color gain value calculated by the color gain calculator.

14. The apparatus of claim 13, wherein the saturation adjustor adaptively adjusts the saturation for each of the pixels of the input image further in consideration of the pattern gain value.

15. The apparatus of claim 13 or 14, wherein the pattern gain calculator determines the input image as the predetermined pattern image if the average of the absolute values is greater than a first threshold, determines the input image as a natural image if the average of the absolute values is smaller than a second threshold, and outputs the pattern gain value corresponding to the input image.

16. The apparatus of any of claims 13 to 15, wherein the predetermined color region is a skin color region.

17. The apparatus of any of claims 13 to 16, wherein the color gain calculator determines whether or not an input pixel belongs to the skin color region by using a 3-dimensional ellipsoidal equation having a mean color value of the skin color region as the center coordinate of the ellipsoid and race- or system-dependent skin color variations as radii of three axes of the ellipsoid and outputs the color gain value according to the result of the determination.

18. The apparatus of any of claims 13 to 17, wherein the color gain calculator determines whether an input pixel belongs to the predetermined color region by using gain functions for Y, Cb, and Cr values of the input pixel and calculates a color gain value for a YCbCr value of the input pixel.

19. The apparatus of any of claims 13 to 18, wherein the mean gain calculator calculates a mean gain value for a mean saturation value smaller than or equal to a first saturation value and for a mean saturation value greater than or equal to a second saturation value, wherein the second saturation value is greater than the first saturation value, to be smaller than that for a mean saturation value between the first and second saturation values.

20. The apparatus of any of claims 13 to 19, wherein the saturation adjustor calculates a local gain value for a saturation value smaller than or equal to a first saturation value and for a saturation value greater than or equal to a second saturation value, wherein the second saturation value is greater than the first saturation value, to be smaller than that for a saturation value between the first and second saturation values.

21. The apparatus of any of claims 13 to 20, wherein the histogram calculator selectively calculates a saturation histogram for the entire frame of the input image or a saturation histogram for pixels in a predetermined window region

of the input image.

22. An apparatus for adjusting the saturation of a color image, comprising:

a saturation calculator (120, 920) which calculates a saturation value for each of pixels of an input image;
a mean saturation calculator (942) which calculates a mean saturation value of the input image using saturation values calculated by the saturation calculator; a mean gain calculator (952) which calculates a mean gain value based on the mean saturation value calculated by the mean saturation calculator; and
a saturation adjustor (170, 970) which calculates a local gain value for each of the pixels using the mean gain value calculated by the mean gain calculator and the saturation values calculated by the saturation calculator and
adaptively adjusts the saturation of each of the pixels of the input image using the local gain value.

23. The apparatus of claim 22, further comprising a histogram calculator (130, 930) which calculates a saturation histogram of the input image using the saturation values calculated by the saturation calculator, wherein the mean saturation calculator calculate the mean saturation value from the saturation histogram calculated by the histogram calculator.

24. The apparatus of claim 22 or 23, wherein the saturation calculator converts an input image signal into an RGB signal and calculates the saturation for each of the pixels as a ratio of the difference between maximum and minimum values of the RGB signal to the sum of the maximum and minimum values of the RGB signal.

25. The apparatus of any of claims 22 to 24, wherein the mean gain calculator calculates a mean gain value for a mean saturation value smaller than or equal to a first saturation value and for a mean saturation value greater than or equal to a second saturation value, wherein the second saturation value is greater than the first saturation value, to be smaller than that for a mean saturation value between the first and second saturation values.

26. The apparatus of any of claims 22 to 25, wherein the saturation adjustor calculates a local gain value for a saturation value smaller than or equal to a first saturation value and for a saturation value greater than or equal to a second saturation value, wherein the second saturation value is greater than the first saturation value, to be smaller than that for a saturation value between the first and second saturation values.

27. The apparatus of any of claims 22 to 26, wherein the saturation adjustor adaptively adjusts the saturation of the input image further in consideration of at least one of a system gain value and a user gain value.

28. The apparatus of any of claims 22 to 27, wherein the input image signal input to the saturation calculator is one of YCbCr, YUV, and YIQ signals.

29. The apparatus of any of claims 22 to 28, wherein when the maximum value of the RGB signal for the input image signal processed by the saturation calculator is less than a predetermined value or is greater than or equal to another predetermined value, the maximum value of the input image signal is not accumulated to calculate the saturation histogram.

30. The apparatus of any of claims 22 to 29, further comprising

a pattern gain calculator (180, 980) which determines whether or not the input image is a predetermined pattern image and calculates a pattern gain value depending on whether the input image is determined as the predetermined pattern image,
wherein the saturation adjustor adaptively adjusts the saturation of each of the pixels of the input image using additionally the pattern gain value calculated by the pattern gain calculator.

31. The apparatus of claim 30, wherein the predetermined pattern image is a test pattern image.

32. The apparatus of claim 30 or 31, wherein the pattern gain calculator calculates the absolute value of a pixel count difference between adjacent saturation regions and an average of the absolute values for all saturation regions of the input image and calculates the pattern gain value using the average of the absolute values.

33. The apparatus of any of claims 30 to 32, wherein the mean gain calculator calculates a mean gain value for a

mean saturation value smaller than or equal to a first saturation value and for a mean saturation value greater than or equal to a second saturation value, wherein the second saturation value is greater than the first saturation value, to be smaller than that for a mean saturation value between the first and second saturation values.

34. The apparatus of any of claims 22 to 33, further comprising:

a color gain calculator (190,990) which determines whether each of the pixels of the input image belongs to a predetermined color region and calculates a color gain value for a pixel depending on whether the pixel belongs to the predetermined color region,

wherein the saturation adjustor adaptively adjusts the saturation of each of the pixels of the input image using additionally the color gain value calculated by the color gain calculator.

35. The apparatus of claim 34, wherein the pattern gain calculator determines the input image as the predetermined pattern image if the average of the absolute values is greater than a first threshold, determines the input image as a natural image if the average of the absolute values is smaller than a second threshold, and outputs the pattern gain value corresponding to the input image.

36. The apparatus of claim 34 or 35, wherein the predetermined color region is a skin color region.

37. The apparatus of any of claims 34 to 36, wherein the color gain calculator determines whether or not an input pixel belongs to the skin color region by using a 3-dimensional ellipsoidal equation having a mean color value of the skin color region as the center coordinate of the ellipsoid and race- or system-dependent skin color variations as radii of three axes of the ellipsoid and outputs the color gain value according to the result of the determination.

38. The apparatus of any of claims 34 to 37, wherein the color gain calculator determines whether an input pixel belongs to the predetermined color region by using gain functions for Y, Cb, and Cr values of the input pixel and calculates a color gain value for a YCbCr value of the input pixel.

39. The apparatus of any of claims 34 to 38, wherein the largest value among the local gain values for the pixels is equal to the mean gain value calculated by the mean gain calculator.

40. The apparatus of any of claims 34 to 39, wherein the histogram calculator selectively calculates a saturation histogram for the entire frame of the input image or a saturation histogram for pixels in a predetermined window region of the input image.

41. The apparatus of any of claims 22 to 40, further comprising:

a peak saturation calculator (140, 940) which determines a peak saturation value of the input image using saturation values calculated by the saturation calculator;
a peak gain calculator (150, 950) which calculates a peak gain value based on the peak saturation value determined by the peak saturation calculator;

wherein the saturation adjustor calculates the local gain value for each of the pixels using additionally the saturation values calculated by the saturation calculator and adaptively adjusts the saturation of each of the pixels of the input image using additionally the peak gain value calculated by the peak gain calculator.

42. A display comprising the apparatus of any of claims 1 to 41.

43. A digital TV comprising the display of claim 42.

44. A digital camera comprising the display of claim 42.

45. A camcorder comprising the display of claim 42.

46. An image processor comprising the apparatus of any of claims 1 to 41.

47. A method for adjusting the saturation of a color image, comprising:

(a) calculating a saturation value for each of pixels of an input image;
(b) determining a peak saturation value of the input image based on saturation values calculated in (a);
(c) calculating a peak gain value based on the peak saturation value determined in (b); and
(d) adaptively adjusting the saturation of the input image using the peak gain value calculated in (c).

48. The method of claim 47, further comprising:

(b1) calculating a mean saturation value of the input image using the saturation values calculated in (a); and
(c1) calculates a mean gain value based on the mean saturation value calculated in (b1),

wherein in (d), a local gain value for each of the pixels is calculated using the mean gain value calculated in (c1) and the saturation values calculated in (a), and the saturation of each of the pixels of the input image is adaptively adjusted further in consideration of the local gain value.

49. The method of claim 47 or 48, further comprising:

(c2) determining whether or not the input image is a predetermined pattern image and calculating a pattern gain value depending on whether the input image is determined as the predetermined pattern image,

wherein in step (d) additionally the pattern gain value determined in (c2) is used for adaptively adjusting the saturation of the input image.

50. The method of any of claims 47 to 49, further comprising:

(c3) determining whether each of the pixels of the input image belongs to a predetermined color region and calculating a color gain value for a pixel depending on whether the pixel belongs to the predetermined color region,

wherein in step (d) additionally the color gain value calculated in (c3) is used for adaptively adjusting the saturation of the input image.

51. A method for adjusting the saturation of a color image, comprising:

(a) calculating a saturation value for each of pixels of an input image;
(b1) calculating a mean saturation value of the input image using saturation values calculated in (a);
(c1) calculating a mean gain value based on the mean saturation value calculated in (b1); and
(d) calculating a local gain value for each of the pixels using the mean gain value calculated in (c1) and the saturation values calculated in (a) and adaptively adjusting the saturation of each of the pixels of the input image using the local gain value.

52. The method of claim 51, further comprising:

(c1) calculating a mean gain value based on the mean saturation value calculated in (b1); and
(c2) determining whether or not the input image is a predetermined pattern image and calculating a pattern gain value depending on whether the input image is determined as the predetermined pattern image,

wherein in step (d) additionally the pattern gain value calculated in (c2) is used for adaptively adjusting the saturation of each of the pixels of the input image.

53. The method of claim 51 or 52, further comprising:

(c3) determining whether each of the pixels of the input image belongs to a predetermined color region and calculating a color gain value for a pixel depending on whether the pixel belongs to the predetermined color region,

wherein in step (d) additionally the color gain value calculated in (c3) is used for adaptively adjusting the saturation of each of the pixels of the input image.

FIG. 1

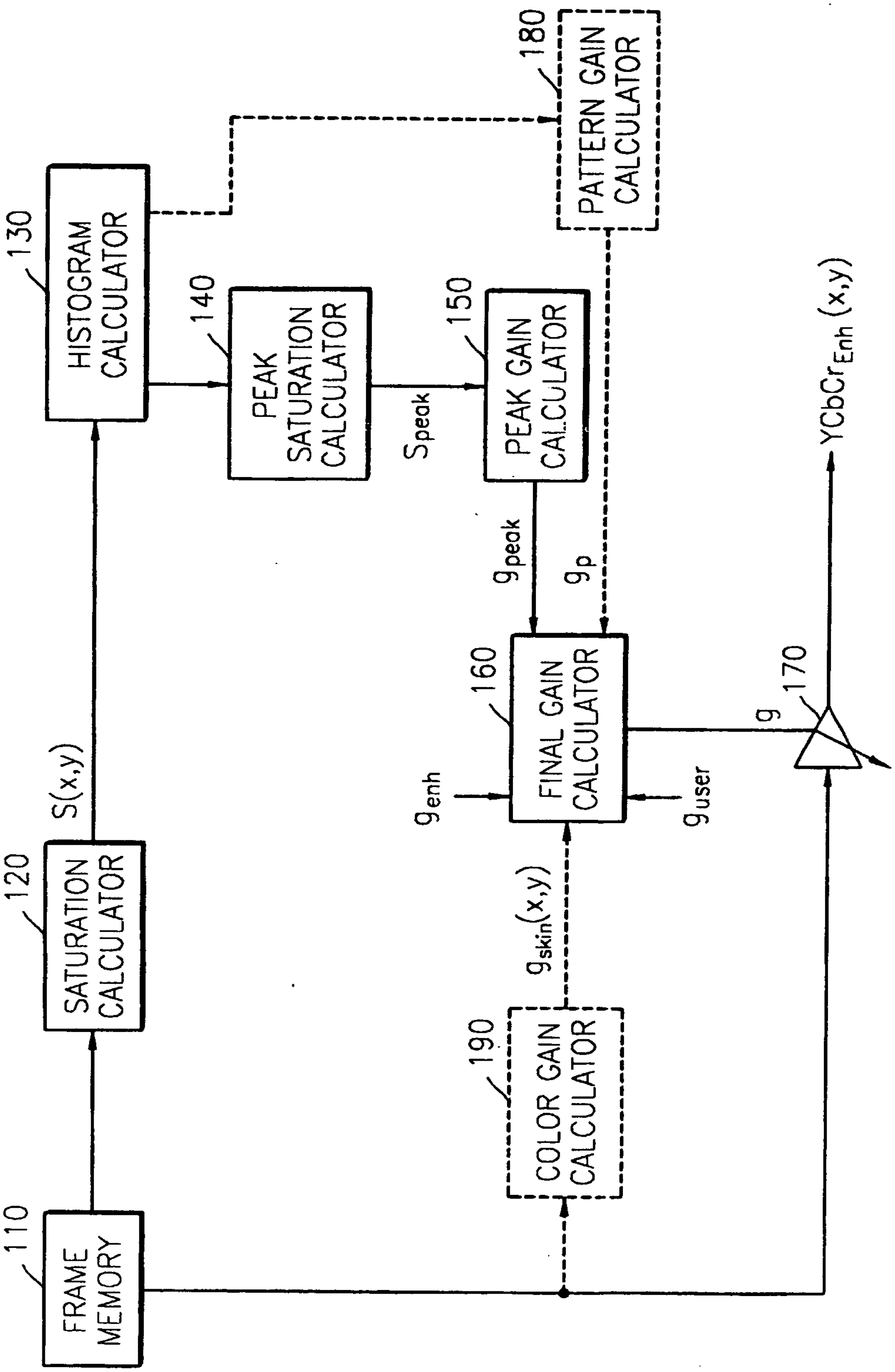

110
FRAME MEMORY
120
SATURATION CALCULATOR
S(x,y)
130
HISTOGRAM CALCULATOR
140
PEAK SATURATION CALCULATOR
S_{peak}
150
PEAK GAIN CALCULATOR
g_{peak}
180
PATTERN GAIN CALCULATOR
g_p
160
FINAL GAIN CALCULATOR
g_{enh}
g_{user}
$g_{skin}(x,y)$
190
COLOR GAIN CALCULATOR
g
170
$YCbCr_{Enh}(x,y)$

FIG. 2

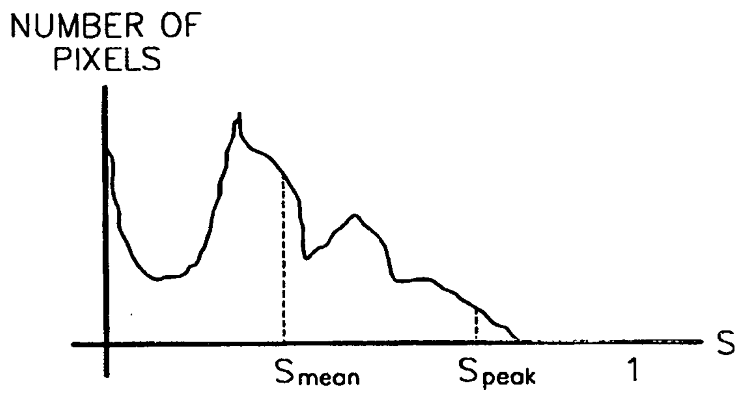


FIG. 3

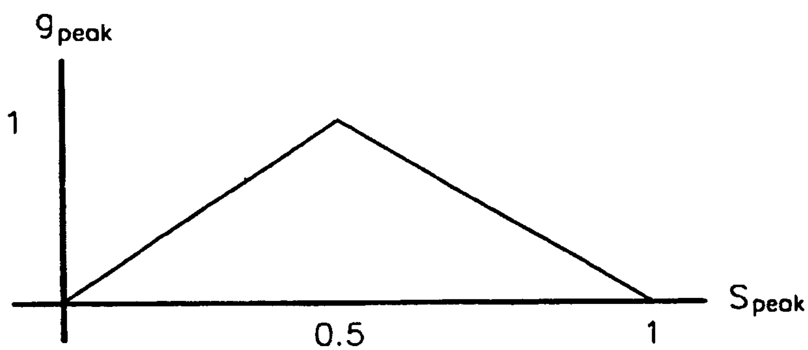


FIG. 4

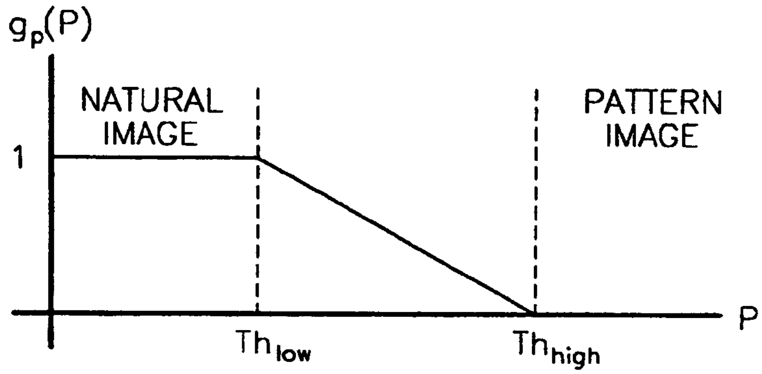
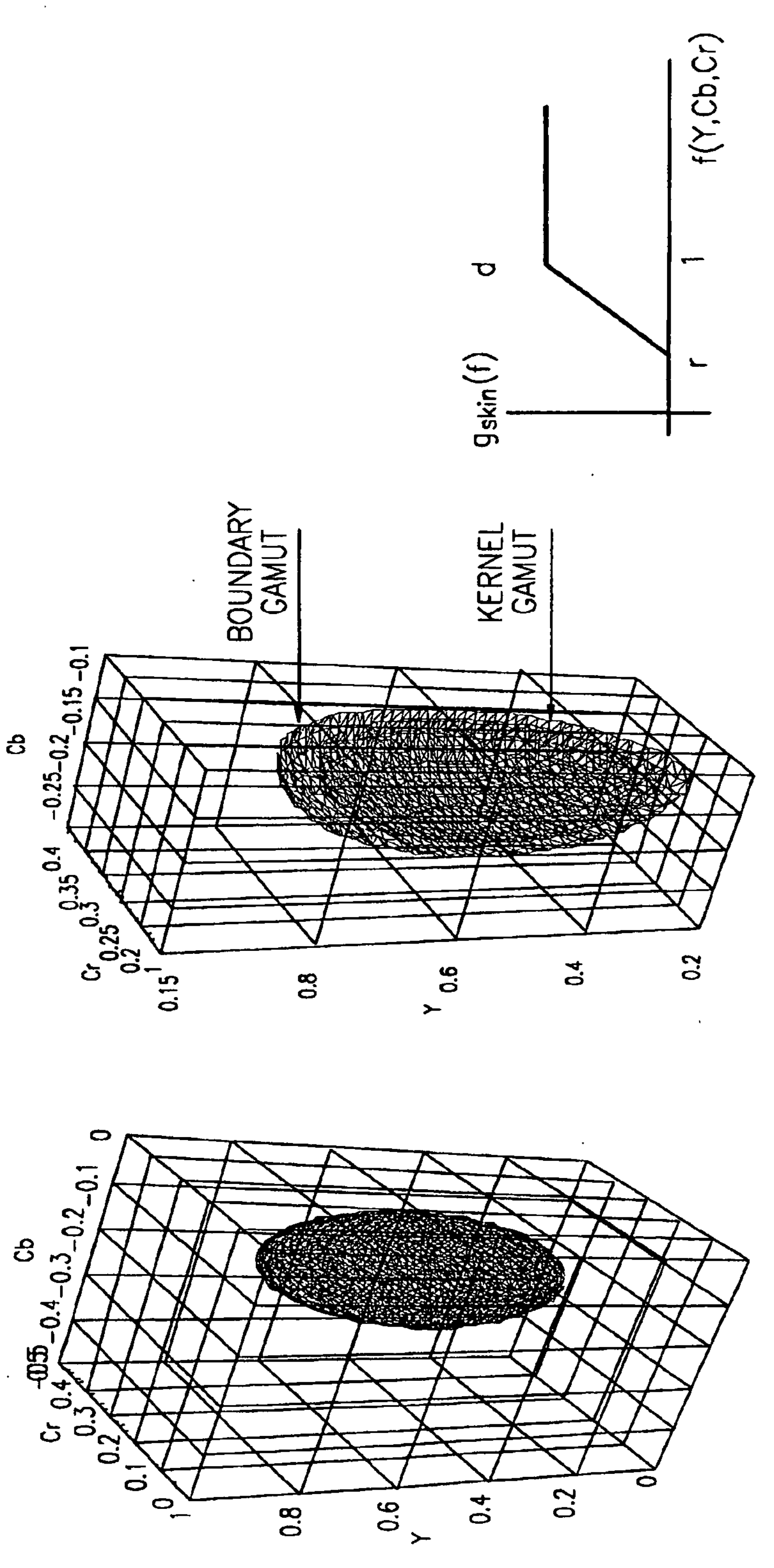


FIG. 5



(a) ELLIPSOIDAL GAIN FUNCTION FOR SKIN COLOR REGION

(b) A QUARTER OF THE ELLIPSOID

(c)

FIG. 6

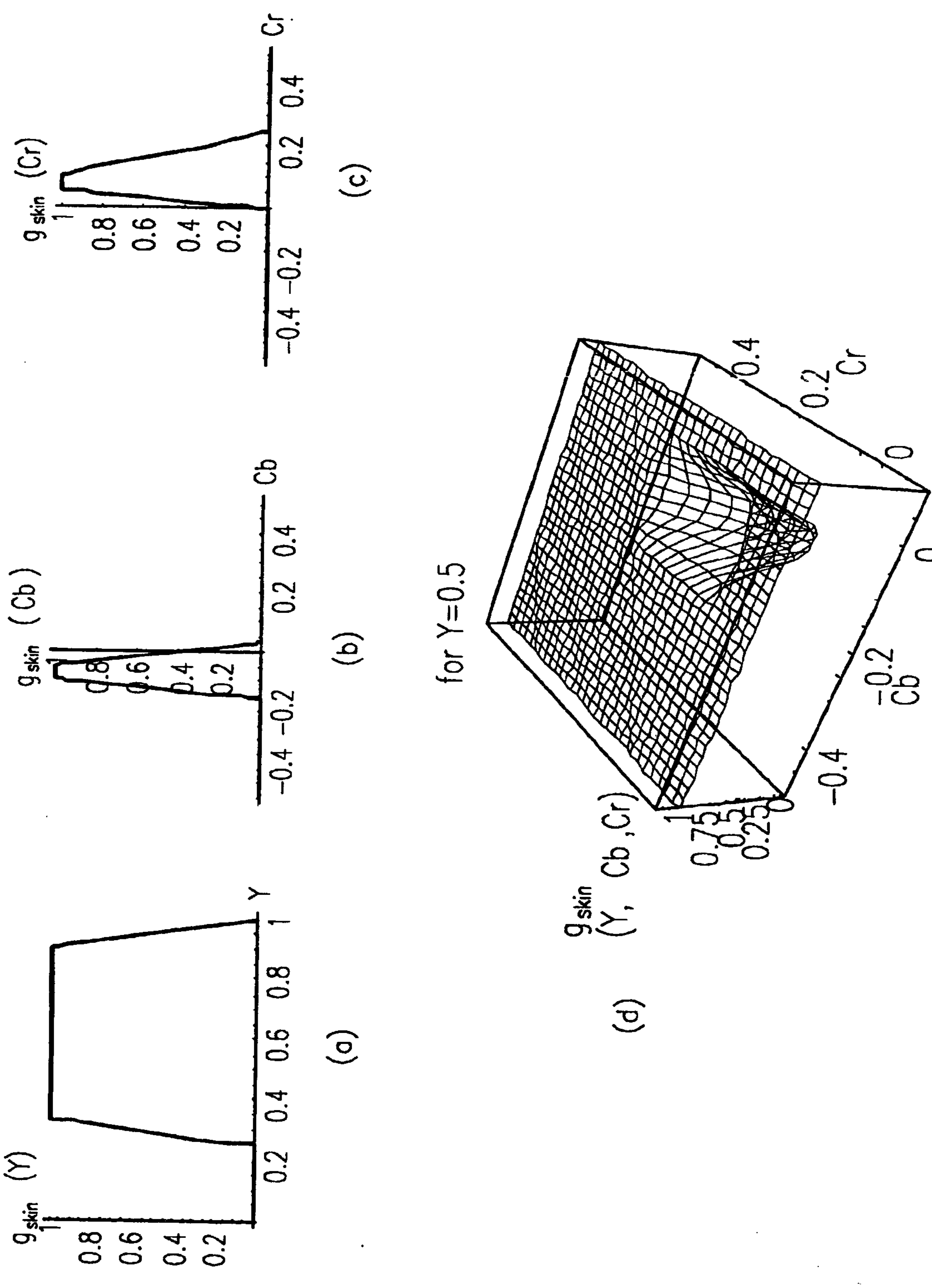
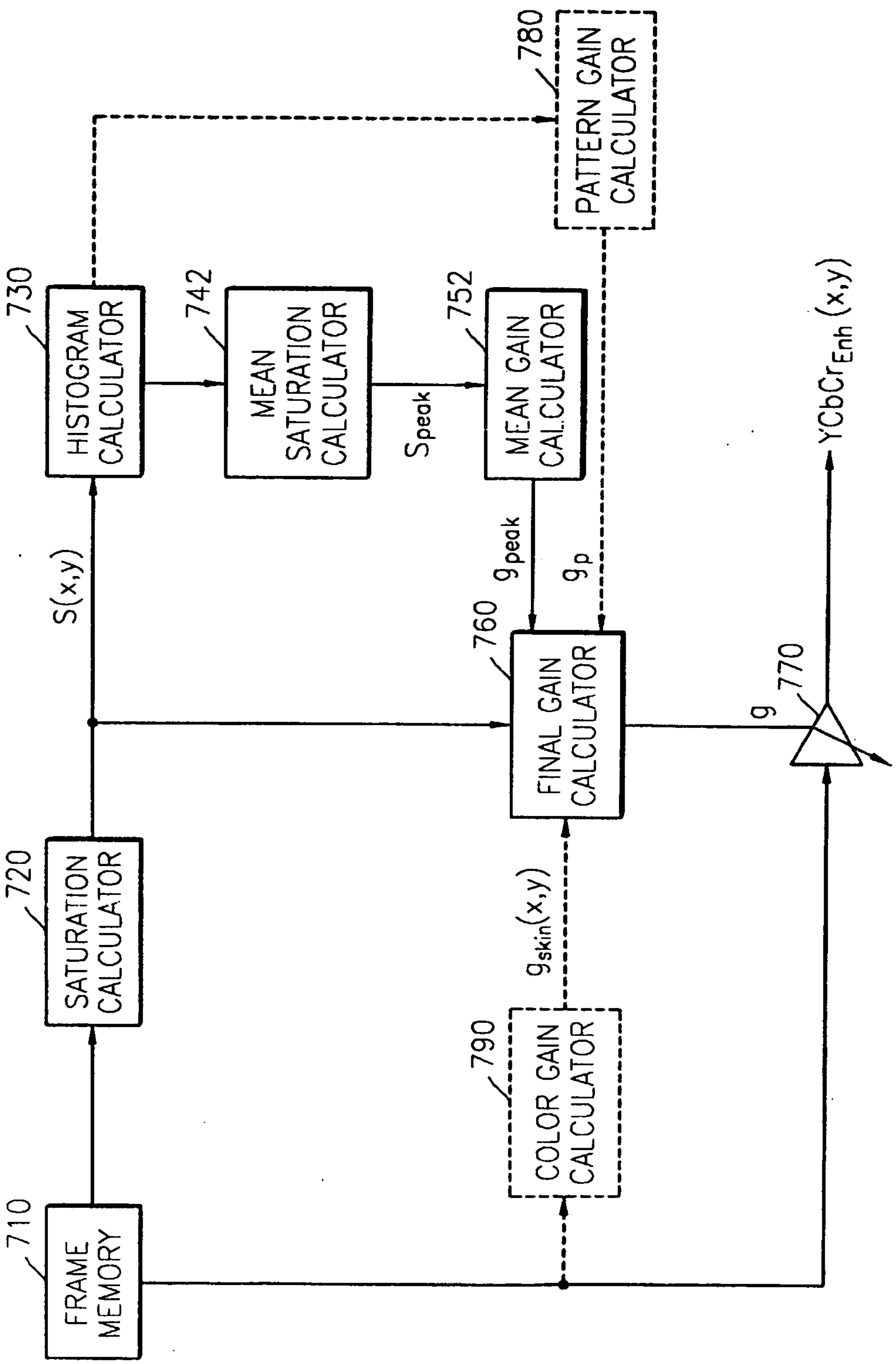

g_{skin} (Y)
0.2
0.4
0.6
0.8
1
0.2 0.4 0.6 0.8 1 Y
(a)
g_{skin} (Cb)
0.2
0.4
0.6
0.8
1
-0.4 -0.2 0.2 0.4 Cb
(b)
g_{skin} (Cr)
0.2
0.4
0.6
0.8
1
-0.4 -0.2 0.2 0.4 Cr
(c)
for Y=0.5
g_{skin} (Y, Cb, Cr)
0.25
0.5
0.75
1
0
-0.4 -0.2 0 Cb
0 0.2 0.4 Cr
(d)

FIG. 7



FRAME MEMORY
710
SATURATION CALCULATOR
720
S(x,y)
HISTOGRAM CALCULATOR
730
MEAN SATURATION CALCULATOR
742
S_{peak}
MEAN GAIN CALCULATOR
752
PATTERN GAIN CALCULATOR
780
g_{peak}
g_p
FINAL GAIN CALCULATOR
760
$g_{skin}(x,y)$
COLOR GAIN CALCULATOR
790
g
770
$YCbCr_{Enh}(x,y)$

FIG. 8A

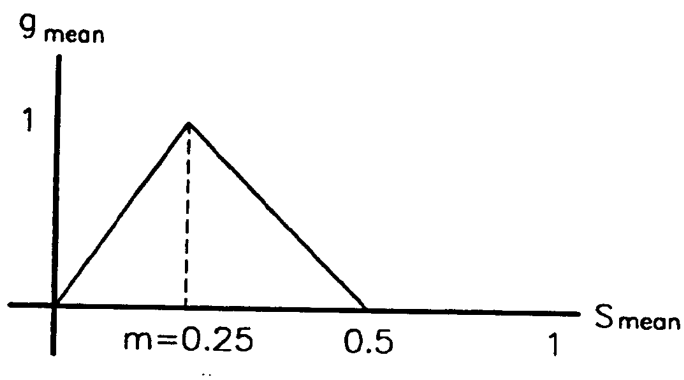


FIG. 8B

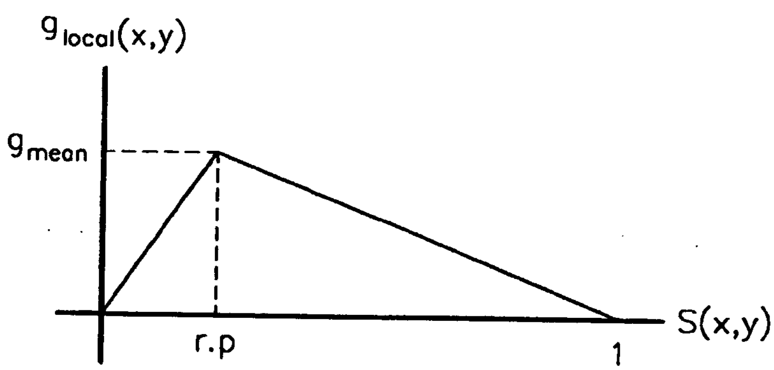
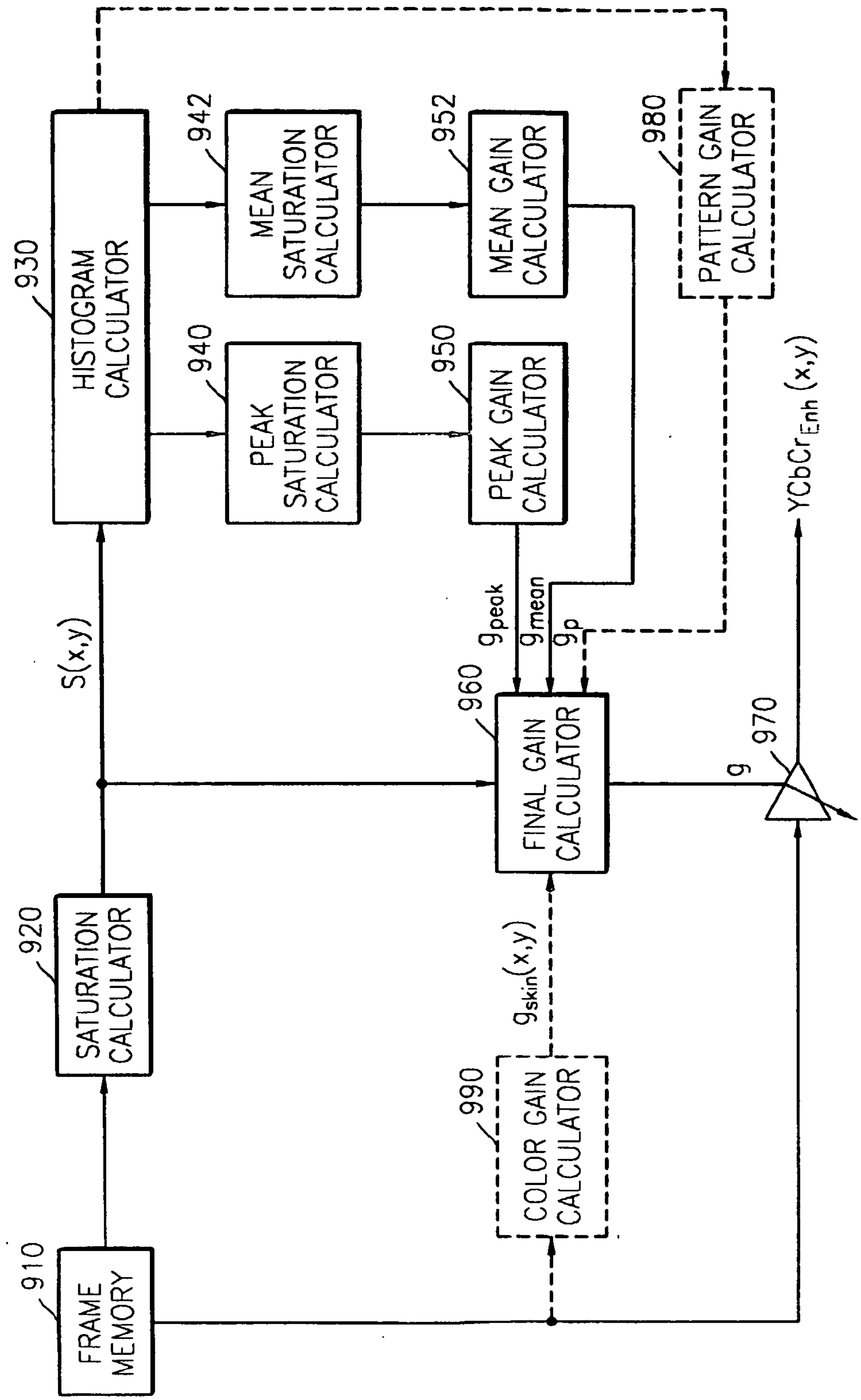


FIG. 9


910
FRAME MEMORY
920
SATURATION CALCULATOR
S(x,y)
930
HISTOGRAM CALCULATOR
940
PEAK SATURATION CALCULATOR
942
MEAN SATURATION CALCULATOR
950
PEAK GAIN CALCULATOR
952
MEAN GAIN CALCULATOR
980
PATTERN GAIN CALCULATOR
g_{peak}
g_{mean}
g_p
960
FINAL GAIN CALCULATOR
$g_{skin}(x,y)$
990
COLOR GAIN CALCULATOR
g
970
$YCbCr_{Enh}(x,y)$